President, in a lecture delivered by him to the British Association at Bradford, that the solar heat, if fully exercised all over the globe, supposing that globe to be entirely covered with water, would be sufficient to evaporate a layer 14 feet deep of water per annum. Now assuming 10 lbs. of water evaporated from the temperature of the air into steam by the combustion of 1 lb. of coal (a much larger result than unhappily is got in regular work), this would represent an effect obtained from the sun's rays on each acre of water equal to the combustion of 1680 tons of coals per annum, or to about 92 cwt. of coal per acre per twenty-four hours; or enough to maintain an engine of 200 gross indicated horse-power day and night all the year round. When, however, we consider the effect of the sun, not upon the surface of water but upon the earth, and deal with its power of producing heat-giving material, the result compares very unfavourably with the work done by the sun itself; and this, no doubt, arises first, from the fact that the sun is frequently obscured, and second, from the fact that a large portion of the energy of the sun is spent in evaporating moisture from the ground, and not in the direct production of combustible material. I have found it extremely difficult to obtain any reliable data as to the weight of fuel grown per acre per annum. If we take the sugar cane, we find that in extremely favourable cases as much megass and sugar together are produced as would equal in calorific effect about five tons of good Welsh coal. Coming to our own country and dealing with a field of wheat, the wheat and straw together may be taken as being equal probably to about two tons of coal as a maximum. The statements made to me with regard to the production of timber per acre per annum, when grown for the purpose of burning, are very various; but the best average I can make from them is that in this country there is produced as much wood as is equal in calorific effect to about 1½ tons of good coal per acre. Comparing these productions of heat-giving material with the energy of the sun, as shown in the evaporation of water, one shows how tempting a field is that of the direct employment of the solar rays as a source of power; more especially, when it is remembered that those rays are obtained from week to week, and year to year, without having to wait the tardy growth of the fuel-destined tree.

I will now ask you to consider with me the prime movers that owe their energy to the heat developed by the combustion of some ordinary kind of fuel—coal or wood. Passing by as a mere toy and not an actual prime mover, the reactionary steam sphere, the eoliopile of Hero, I will come at once to those simple forms of heat-engine (whether worked by steam or the expansion of air), by which water was to be raised. Solomon de Caus, in his work of 1615, already mentioned, says that if you fill a globe with water and have in its upper part a pipe dipping nearly to the bottom, and if you put the globe upon the fire the heat will cause the expansion of the contents, and the water will be delivered in a jet out of the tube.

The Marquis of Worcester in his "Century of Inventions," published in 1659, makes, as is well known, a similar proposition, but it does not appear that these machines were seriously contemplated for practical use. Papin (I take Belidor's Article No. 1,276 as my authority) in 1698 (as appears in his pamphlet of 1707) experimented by order of Charles the Landgrave of Hessen Cassel with the view of ascertaining how to raise water by the aid of fire. But his experiments were interrupted and he did not resume them until Leibnitz, by a letter of Jan. 6, 1705, called his attention to what Savery was doing in England, sending him a copy of a London print of a description of Savery's engine. This engine, which of course is well known to you, is illustrated by a model in this collection, and now on the table before me. Savery employed a boiler, the steam from which was admitted into a vessel furnished like the sun-pump of Belidor with a suction pipe and clack and a delivery pipe and clack; the steam being shut off, cold water was suffered to flow over the vessel, a vacuum was made and water raised into the vessel, which was expelled out of the delivery pipe upon the next admission of steam, the cocks being worked by hand. This machine came into very considerable use and was undoubtedly the first practical working steam-engine. It had, however, the defect of consuming a large quantity of steam, as the steam not only came into contact with the cold vessel but also with the surface of the water in that vessel. Papin, as we know, obviated a portion of this loss by the employment of a floating piston placed so as to keep the steam from actual contact with the surface of the water.

We have in the collection, No. 2,007, a cylinder from Hessen Cassel, said to be of the date of 1699 and to have been intended for employment in Papin's machine, but it is difficult to say for what part of the apparatus it could have been designed, inasmuch as the cylinder is provided with a flange at one end only and no means, so far as I can ascertain, exist for closing the other end. You will see from the diagram that which no doubt is already well known to you; Papin did not propose to condense the steam, and by its condensation to "draw up" the water (to use a familiar expression) but intended that the vessel should be charged by a supply from above, and, that the steam should be employed only to press on the floating piston and to drive the water out. Papin, however, hoped to use his engine, not merely as a water-raiser, but as a source of rotary power by allowing the water to issue from the air vessel, so as to impinge upon the pallets of a water-wheel and thus produce the required revolution.

(*To be continued.*)

SCIENTIFIC SERIALS

American Journal of Science and Arts, May.—Mr. Holden here collates various observations made on nebula M 17 (the figure of which is like that of a Greek capital Omega) from 1833 to 1875. The drawings show that the western end has moved relatively to its contained stars, and always in the same direction. It may be a veritable change in the structure of the nebula itself or the bodily shifting of the whole nebula in space.—Mr. Trowbridge states that the application of thin plates of soft iron on the poles of two straight electro-magnets, with bundles of fine iron wires for cores, increases the strength of the spark at the poles of two secondary coils surrounding the electro-magnets, 400 per cent. The length of the spark is increased 100 per cent. (but this is only manifested by using Leyden-jars of large capacity with the secondary circuit). Instead of distributing the fine wire of a Ruhmkorff coil on a straight electro-magnet, as at present, it should be distributed equally on two straight electro-magnets whose poles are provided with armatures of bundles of thin plates of soft iron.—Mr. Wilson having applied infusorial earth to land sown in wheat, afterwards treated some of the wheat straw with nitric acid, and found that the siliceous remains consisted almost wholly of the shields of diatomaceæ, the same as found in the infusorial earth (only the larger discs, in their perfect form, being absent). It would appear that simple or compound silicates are useless as fertilising agents, and that silica can enter the plant only in the free state.—In the first portion of a paper on the solid carbon compounds in meteorites, Mr. J. Laurence Smith, after noting that in carbonaceous meteorites the mineral constituents are mainly the same as in the so-called common type of meteoric stones (viz., olivines, and pyroxenes, differing only in the more or less compact form of these minerals), shows, that even in the carbonaceous constituent they are strongly linked even to the iron meteorites.—Mr. Fontaine continues his account of the conglomerate series of West Virginia; Mr. Dana describes new forms of staurolite and pyrrholite; and we also find chemical notes on phosphorus oxychloride, and the oxydation product of glycogen with bromine, silver oxide, and water.—A simple and very accurate method of testing the unison of two forks is (according to Mr. Spice) by holding them *together* over their proper resonant column; if the forks be *very* nearly in tune, beats will be perceived succeeding each other at long intervals, or the sound will merely swell out again very slightly after it has nearly died away. When the forks are absolutely alike, there will be a gradual decrease of sound down to silence, without any reinforcement at any time.

THE *American Naturalist* for May commences with an article by the Rev. S. Lockwood, on Animal Humour. Prof. Asa Gray writes on Wild Gooseberries. Hon. J. D. Cox describes multiplication by fission in *Stentor mülleri*. An article on Primitive man follows, after which Mr. A. S. Packard, jun., describes and figures the Cave-beetles of Kentucky. Prof. Farlow writes on University Instruction in Botany. General Notes and a few short reviews follow, the number being completed by notes and notices of meetings.

Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie, March 1.—This number contains a long article on the relations of temperature and moisture in the lowest atmospheric strata during the formation of dew, by Dr. R. Rubenson, of Stockholm. Observations made by Dr. Hamberg, at Upsala, on temperature at different heights on frosty nights led him to conclude that in the lower strata temperature increases with height, and that the

absolute moisture is less on the ground than a few feet above it. The chief results obtained by Dr. Rubenson during the summer of 1871, by a method of observation differing from that of Dr. Hamberg, may be summed up as follows:—Before the fall of dew the absolute moisture continues to increase and is greatest on the ground, diminishing with height. As soon as dew begins to fall, moisture decreases on the surface of the ground, and this decrease keeps pace with the decrease of temperature. The decrease of moisture extends upwards rather rapidly, and can be detected at four feet just after the first deposition of dew. On the ground the decrease per hour amounts to a maximum of about 0·73 mm., while half a foot above it the decrease only reaches 0·65 mm., which is less than one corresponding to the lowering of temperature. The higher the instrument the later does the decrease of moisture show itself, and the less the change per hour. It appears that owing to a fall of temperature on the ground, the air immediately above it becomes saturated, dew falls, and temperature and moisture diminish. At a certain point, owing either to diffusion or a descending current, fresh vapour supplies the place of that condensed as dew, and part of the loss of each stratum is successively made up by the moister stratum above it, but not the whole, for the diminution continues in all the strata. Time being required for the propagation of the decrease upwards, the lowest stratum loses more of its moisture than any of the strata above it.

Zeitschrift für Wissenschaftliche Zoologie, 1875. 2nd Supplement.—This part contains a memoir by Oscar Schmidt, on the embryology of calcareous sponges, in which Haeckel's observations and conclusions are attacked, and his Gastræa theory is destroyed, as far as calcareous sponges are concerned. Unfortunately, at a critical point Oscar Schmidt failed to follow his embryos, and the real purport of his observations remained uncertain until the publication of Schulze's researches hereafter mentioned.—Dr. William Marshall contributes a long memoir on the hexactinellid sponges, figuring and describing new species, with their characteristic spicula. His most interesting new form is one in which the central cavities of the spicula coalescing to form the meshes of the skeleton become perfectly continuous by their protoplasmic contents.

The 3rd Supplement (1875) commences with F. E. Schulze's memoir above referred to, on the structure and development of *Sycandra raphanus*. His beautiful figures give the various stages of segmentation, and the arrangement of the segmentation spheres into groups of different sizes, one set of these giving rise to the invagination by which the Gastrula form is constituted. This sponge is now accepted by Haeckel as exemplifying his Amphiblastic type, while other calcareous sponges form archiblastic embryos, in which the segmentation spheres remain similar to one another until after the Gastrula is formed.—August Weissmann contributes a philosophical paper on the transformation of the Axolotl into Amblystomas. He believes that this transformation is to be regarded as a retrogression, and that the present Axolotl represents a former Amblystoma whose structure has been modified by changed conditions of life.—Prof. Nitsche continues his valuable memoirs on the Bryozoa, the present instalment being devoted to the process of gemmation. He shows that all the structures in the new zooid are produced from the ectoderm of the parent, and insists on the important morphological consequences of this fact, while deprecating the precise schemes of embryogeny and phylogeny now so much in vogue.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 11.—On Simultaneous Barometric Variations in India, by J. A. Broun, F.R.S.—After Pascal showed that the mercury in the barometer tube stands lower at the top than at the foot of a mountain because the mass of air above the barometer is less in the former than in the latter case, it was a natural conclusion that the variations in the height of the mercury observed with a stationary barometer are due to the same cause. Various hypotheses have been proposed to explain how the aërial mass is increased or diminished, none of which, however, can satisfy the facts now known, being either insufficient or untrue. The author, after referring to the latest of these hypotheses, gives results which he has deduced from observations made at three stations in India; namely, at Simla, 7,000 feet above the level of the sea, on a spur of the Himalayas, at Madras, and at Singapore, near the sea-level, the last being 2,700 miles from the first, and 1,800 miles from the second station.

When the daily mean height of the barometer is taken, a large movement is found occupying nearly twenty-six days, a movement attributed by the author to the sun's rotation on his axis; but it is the smaller oscillations of the daily mean atmospheric pressure, the secondary maxima and minima, which are especially examined. The present discussion has been limited to three months, during which there were eighteen of these maxima and minima. The author finds that the mean interval between the times of maximum pressure at any two stations is less than seventeen hours, and between the times of minimum pressure less than ten hours. In four out of eight cases of minima the lowest pressure was attained at all the three stations within six hours. The results of these comparisons is shown to extend even to St. Helena.

It was pointed out that though in general maxima and minima happened at the three stations near the same hour, there were one or two marked exceptions to the rule; one of these, a fall in the height of the mercury of three-tenths of an inch within thirty-six hours, at Simla, was not perceived at any of the other stations. This, the greatest of all the disturbances of atmospheric equilibrium during the period examined, was shown to be connected with a great thunderstorm at Simla (not felt at the other places), and was thus due to a local cause, while the other variations, some of about one-thirtieth the amount of that just mentioned, happened nearly simultaneously over an area of at least a million square miles.

The author suggests that another cause is required to explain these facts than variations of mass through thermic or other actions, the whole climatic conditions being different at the various stations; in other words, *that the attraction of gravitation is not the only attractive force concerned in the variations of atmospheric pressure*.

Linnean Society, May 24.—Annual General Meeting.—Prof. Allman, F.R.S., president, in the chair.—There were presented by Mrs. J. J. Bennett, and a vote of thanks accorded, three medals, memorials of Linnæus—one of silver, struck in 1746, given by Linnæus to Haller in exchange for his portrait; one of gold, dated 1747, struck at the expense of Count Tessin; and a large silver one, designed by Lynberger, struck by command of the King of Sweden in commemoration of the death of Linnæus, Jan. 10, 1778.—Mr. J. Gwyn Jeffreys, treasurer, read his statement of the accounts, &c., of the Society for the year 1875. These showed its financial position to be very favourable, and, indeed, prosperous. The increase in the number of Fellows was very marked, and everything augured the Society's retaining their well-earned reputation and usefulness as a scientific body.—The President then delivered his anniversary address, choosing as a topic the department of biology, treating of those remarkable forms, the border-land between vegetable and animal life. He began by allusion to De Bary's researches on Myxomycetes and its curious transformations; then referred in detail to Cienkowski's remarkable observations on Vampyrella and the marine sarcodous organisms, Labyrinthulæ. Dr. Archer's Chlamydomyxa, Haeckel's Myxastrum, and Magosphaerica, were each passed in review, and a comparison of all these forms entered into, with their peculiar phases and relations to each other. He observed that in them protoplasm was reduced to its simplest nature, evincing what might be considered vegetative or animal life, according to stage, &c. He summed up by regarding life as a property of protoplasm, but very different from conscience and will, or indeed any of the psychological phenomena. The following Fellows were elected into the Council:—J. G. Baker, Dr. W. P. Carpenter, Henry Lee, Prof. W. K. Parker, and S. J. A. Salter, M.B., in the room of the subjoined, who retired: W. T. T. Dyer, J. E. Harting, W. P. Hiern, M.B., Dr. J. D. Hooker, C.B., and J. J. Weir.

Chemical Society, May 18.—Prof. Abel, F.R.S., president, in the chair.—A paper on hemine hematine and a phosphorised substance contained in blood corpuscles, by Dr. J. L. Thudichum and Mr. C. T. Kingzett, was read by the latter.—Prof. W. N. Hartley then made a communication on the natural carbon dioxide from various sources, being a continuation and extension of his former paper on the presence of liquid carbonic anhydride in the cavities of quartz and other minerals.—Mr Kingzett subsequently read a note on some trials of Frankland and Armstrong's combustion process *in vacuo*, by Dr. Thudichum and himself.—Mr. T. Fairley gave a short account of three papers on